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Evidence suggests reading ability is related to other communication skills such as listening and speaking. Disruption in the process of receiving, analyzing, and utilizing auditory stimuli may have deleterious effects upon a child's development of reading skills, especially if this disruption occurs in pre-school children. Those growing up in noise-filled slum areas may, thus, need auditory discrimination training in order to derive maximum benefit from reading training. Kindergarten may be the optimum time for this training.

Studies show that the Wepman Auditory Discrimination Test correlated with few other measures of verbal skills. More significant relationships were found between Wepman scores and verbal measures for retarded readers than for normals and more for first graders than for fifth grade children among subjects unselected for reading ability.

Characteristics of poor readers were found to be that they have more difficulty with auditory discimination, more difficulty with shifting between visual and auditory modalities, and they are more inefficient at a serial learning task when the stimuli are auditory rather than visual. Here again the performance of poorer readers related to better parallels that of younger children as compared with older. This tends to support De Hirsch's hypothesis of "neurophysiological immaturity" in many children with reading and language difficulties. One can thus postulate that a minimum level of auditory discrimination skill is necessary for the acquisition of reading and of general verbal skills. Once that minimum level is reached auditory discrimination may no longer be highly correlated with these abilities.

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AUDITORY DISCRIMINATION AND LEARNING: SOCIAL FACTORS

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Auditory Discrimination and Learning: Social Factors

Lynnis P. Dunkel[1]

This paper will deal with events in only one of the various modalities through which school are tested, processed, and evaluated for their reception, perception, or will not be concerned primarily with hearing itself per se, and its subsequent and limited but certainly with the discrimination of sound from another, and with the recognition of sounds and their patterns. Discussion of these latter functions presupposes a normal receptive sensory apparatus. Detailed knowledge of sensory modalities and of abnormalities in sensory sensitivity does not imply exploration of these other variables, but limitations in the space-bound confines of papers to be read at conferences. It must be added, though, that the early data gathered at the Institute pointed to auditory discrimination as an exceedingly important factor in verbal behavior, and as a result, further studies have supplied much more information about auditory discrimination than about similar functions related to other modalities.

The importance of accurate input to appropriateness of response does not need belaboring. It is well illustrated in the visual world of Mr. Magoo, or in the story of the three deaf old ladies on the train, in which the first says to the second, "What time is it?"; the second replies "Thursday."; and the third says, "So am I. Let's go get something to drink." Both Mr. Magoo and the three ladies had misperceptions because of the inadequate sensitivity of

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[1] I should like to express my appreciation to Jere Brown, Estelle Cherry, Richard Coleman, and Barbara Wich for the preparation of the tables cited here, and for their inestimable helpfulness in getting the proper statistical comparisons run at what were all too often inconvenient times. In addition, I have had the benefit of many stimulating conversations with colleagues on the topics discussed in this paper.

the basic receptors, and presumably all would come to appropriate conclusions if their receptors were sensitive enough to be activated by the stimuli with which they were presented. Thus, one cause of inaccurate input is insensitivity of the receptor itself, so that the information which reaches the analyzing or interpreting areas of the brain is inaccurate or incomplete. This same result can occur, of course, if the stimulus intensity is below the threshold value for a normally sensitive receptor. When this happens, the tendency is for the missing stimuli to be supplied internally, as was shown in the experiments on subliminal stimulation, and as can be seen in the children's game of "telephone" as well as in the examples given above.

In all the examples given, the sensory input which reaches the analyzing centers is faulty, whether through abnormal insensitivity of the receptor or because of sub-threshold values of the stimulus. The analyzer, so to speak, does the best it can with what it gets, the percept is formed, and the response is faulty or inappropriate because of this inaccurate feedback.

After simple sensitivity, the next level of sensory response which can be considered is discrimination. This is a function which corresponds to the stimulus property of frequency. Discrimination is, of course, impaired by inadequate receptor processes, but it is possible to have intact end-organs and still be unable to discriminate differences in tone or between particular sounds. This kind of disability blends into a third level of function defined by Mundy (1962) as recognition--the ability to name or reproduce a particular sound or word. These functions apparently are subsumed

by the higher nervous centers, and in the case of auditory stimulation, presumably by the temporal lobes and the temporal-parietal regions of the brain. It is possible, thus, to have fully intact end-organs--i.e., to have vibrations received and transmitted by the ear--and still not to discriminate or to understand or recognize sounds, if there are lesions in the crucial cerebral areas.

However, for discrimination and recognition, another set of variables is as crucial as the intactness of the brain: these are variables having to do with experience and exposure to the adequate stimuli. Thus, one might have fully adequate auditory sensory apparatus, both peripheral and central, and yet, on being exposed to a spoken foreign language for the first time, be unable to recognize any referents or meanings to the words heard, and, perhaps, also find it difficult or even impossible to discriminate sounds or words from each other. These discriminations come only with experience and practice in responding to the stimuli. A better example for purposes of the following discussion would be the infant, who hears but who does not discriminate or recognize. It is only through experience which involves consistent exposure to particular auditory stimuli that the baby comes to discriminate sounds, to recognize words and relate them to their referents, and ultimately to use words himself. The gross link between hearing and speech is thus an obvious and well-established one. But there is no reason to suppose that the relationship is a unitary one, unaffected by the quality or consistency of the speech which the child hears, or by the circumstances under which the stimulation occurs. People speak consistently with the local dialect which surrounds them. These

facts are well known, and most school systems, for example, require speech tests as part of the teacher-licensing procedure to insure that the children in school will be exposed to standard, correct speech.

This perhaps already obvious point has been somewhat belabored in the interests of underlining the importance of experience and exposure in the development of speech and of language. Thus far, only the gross aspects of stimulation have been dealt with. But other facts and current theories of sensation and perception are here pertinent. For example, the reticular system, which seems to be responsible for a general, over-all activating function in the nervous system, without which no stimulus is effective, is able to influence transmission of sensory messages within the central nervous system. Animal experiments show that when the reticular system is directly activated, sensory transmission is inhibited or facilitated, depending on where the activating stimulus is applied (Hernández-Péon, 1961). Experiments by Hernández-Péon (1961) and others indicate that activation of the brain-stem reticular formation inhibits auditory transmission very early in the path of that transmission. In addition, it has been found in cats that auditory evoked potentials are reduced when the animal is attentive to stimuli in other modalities (Hoch-y-Rita et al., 1961, reported in Hernández-Péon, 1961). Similarly, the potentials in other modalities are reduced when the animal's attention is on an auditory stimulus. It was also found that afferent messages elicited by stimuli which are attended to are facilitated.

It is not planned here to make the sometimes tempting but always

erroneous direct translation from animal experimentation to human functioning or behavior, but the animal experiments do provide hypotheses about functioning in the human nervous system, and these hypotheses can be viewed in the light of behavioral data which are available or which can be gathered. In these terms, the findings from these animal experiments on the reticular system are consistent with the information-theory findings that the signal-to-noise ratio is influential in the stimulus perceived and in the response evoked. The higher the ratio--i.e., the greater the amount of "signal" as compared with "noise"--the more likely will be the accurate perception of the signal. This formulation is, of course, consistent with the Gestalt formulations regarding figure-ground relationships in visual perception. The theoretical as well as actual importance of the environment also has roots in Gestalt perceptual theory.

To return, though, to the postulated relationship between the reticular system and the signal-to-noise ratio, one could hypothesize that with a low ratio--i.e., with a lot of noise in the system--the excess activation of the reticular system is interfering with the travel of the signal up the neural paths. There are some human learning experiments which show that some "noise" in the system is beneficial for learning, while too much is disorganizing. One could hypothesize, again, that this finding has to do with reaching a level of activation which prepares the organism to accept and respond to a stimulus, but not exceeding that optimal level and thereby producing a blocking out of the desired stimulus. Similarly,

human learning explanations on repetitiousness of stimulation and animal studies on habituation to consistent stimulation are in agreement: i.e., perception of the stimulus can be dulled or abolished by continued identical presentation. This last assumption can be further verified by the casual observation that continued stimuli to which we become accustomed (i.e., to which we adapt) are blocked out, such as random street noises outside a home or office, or the noise of machinery with which one works. Myklebust's (1960) differentiation of modalities is pertinent here: he classifies vision and hearing as distance senses, but points out that hearing is largely a background sense, since auditory stimuli are always present: we are unable to avoid the impingement of the physical properties of sound. Therefore, we might postulate that auditory stimuli are particularly prone to a "tuning-out" process, to a learned inattention.

Granting, for the moment, the accuracy of these hypotheses, one could expect that a child raised in a very noisy environment with little directed and sustained speech stimulation might well be deficient in his discrimination and recognition of speech sounds. He could also be expected to be relatively inattentive to auditory stimuli, and further, to have difficulty with any other skill which is primarily or importantly dependent on good auditory discrimination. The slum child does indeed live in a very noisy environment, and he gets little connected and concentrated speech directed to him. If indeed he does show poor auditory discrimination, and if for the most part the sensitivity of the end-organ is normal, then the hypothesized process by which the poor

discrimination is produced would point to methods of alleviation. Since data to be presented later seem to indicate the importance to reading skill of accurate auditory discrimination, and since lower-class children show a much greater incidence of reading retardation than the children from more privileged backgrounds, alleviation of difficulties in auditory discrimination would appear to be potentially highly important.

This reasoning implies certain desirable conditions for children's auditory learning: One would try to place the child in a quiet environment and minimize stimuli to other modalities while maximizing the particular auditory stimuli which are being presented (i.e., maximize the signal-to-noise ratio). Further, one would want to avoid too much repetition of the same stimulus, while at the same time avoiding presentation of too many different stimuli which might in themselves be distracting. This is almost an operational definition of good and approved teaching technique, and it is indeed illuminating to discover the experimental and theoretical path by which it was arrived at!

But all the foregoing was not just a pleasant exercise on an unfamiliar path with the goal of arriving at a familiar courtyard. Nor is it simply a fancy justification for educational desiderata. Rather, the path can be both a principle against which educational innovations can be evaluated, and, more important, it can open up wide areas of research in fields peripheral to education and can perhaps point the way to the objective measurement of "distraction" or "quiet" for particular children and particular learning situations.

By discovering ways in which knowledge in seemingly disparate areas can be brought to bear on common problems, new knowledge and new techniques for obtaining more knowledge can also be found. But further, and possibly most important, other variables, perhaps previously not considered, can be evaluated for potential import to the problem at hand.

If we correctly place the problem of auditory discrimination (in the absence of serious disability in the nervous system) in the environmental organization of auditory stimuli, then we must also consider the developmental level of the child when he is exposed to the various auditory organizations. It is known that there are certain optimal times for various stimulation, and that, in fact, in some areas there are also critical times--times within which a given type of stimulation will be effective and outside of which it will not. Such concepts of optimal and critical times are well established in biology, and are becoming so in biopsychology and in theories of animal behavior. Again, from this work, certain principles can be adduced which can be tested against the phenomena of human behavior. It is already known that foreign languages, for example, can be most easily learned by normal children relatively early in life, but after their basic language is established. Similarly, it is known that, for the most part, the complex type of motor coordination necessary for, for example, riding a bicycle, is most easily acquired in childhood rather than adulthood. (Whether this is largely because of the greater plasticity of the motor patterns or because of the poorer cognizing of events connected

with falling off and the simultaneous greater resiliency of the physical structures in the event of falling is, for purposes of this discussion, immaterial. What matters is the fact that it is more possible to learn to ride a bicycle earlier in life than it is later in life.) It was shown in the studies of persons who gained vision after being blind for all their lives up until surgery that, after a certain age, pattern vision could never be acquired if there had been no earlier visual stimulation. (These findings are consistent with those on chimpanzees reared in the dark for varying lengths of time.) Thus, concepts of optimal time are not new to human behavior theory.

In educational circles, the concept has been most often transformed to the idea of "readiness" and the most frequent use of this concept has been to delay certain kinds of teaching. That is, the emphasis in "readiness" is on waiting for a more optimal time. In biology and in animal psychology, on the other hand, the most frequent emphasis has been on providing particular stimulation early enough. Only in theories of personality, in discussions of psychopathology, and in some orientation to some motor skills have theorists of human behavior emphasized the importance of early correct stimulation or treatment.

In a recent article bearing on this issue, Scott (1962) points out that "...organization inhibits reorganization. Further, organization can be strongly modified only when active processes of organization are going on." He states, further, that it is this fact that "accounts for critical periods in development." He

hypothesizes, on the basis of data which he presents, that the "critical period for any sort of learning is that time when maximum capacities--sensory, motor, and motivational as well as psychological ones--are first present." This places the emphasis squarely on earlier, rather than later, stimulation and teaching, and places the evaluation burden on discovering the developmental progress of the particular capacities which are to be stimulated. Scott's position here, though largely theoretical and not based on data on children, is very similar to Fowler's (1962) in his argument for the efficacy of pre-school training.

While we do not at present know precisely the time at which the maximum capacity to develop auditory discrimination is reached, nor do we know the exact maturational sequence in discrimination difficulty of various types of sounds, we do know that by the time children come to the first grade, many of them already have poor discrimination abilities organized, and following Scott's dictum that "organization inhibits reorganization" we can assume that a better time to train good auditory discrimination would be before first grade entrance. From here it is not, I hope, too unwarranted a leap to the hypothesis that the optimal time for such learning must be before the age at which children enter the first grade.

In considering the slum child from this point of view, then, we must conclude that at his optimal time for learning auditory discrimination--sometime in his pre-school years--he is confronted with a very poor situation for this learning: a very noisy environment, and one with many distractors and low signal-to-noise ratio. Thus, at a time when he might most easily learn discriminations, he

is encouraged by the stimulus properties of his environment to become inattentive to the appropriate stimuli, and, in fact, perhaps to block out many of them altogether. Further, there is some evidence for a kind of "Gresham's Law" in auditory stimuli: Cherry (1961) reports that when a "noisy" noise is fed into one ear at the same time that a "purer" noise is fed to the other, the "noisy" noise blocks out the purer one. Another factor which may serve as an impediment to his development of good auditory discrimination skills is the fact that in New York City at least, the child from the over-crowded living area is assailed by numerous dialect patterns, so even the relatively weak signal in the environment of noise is not a consistent one.

Now, from the fact that foreign languages can be learned at almost any age (albeit with more effort and often more slowly) and similar related data, we can hypothesize that such learning has optimal times but not critical times--that is, that there is no cut-off time beyond which such learning cannot take place. While it does not therefore follow that auditory discrimination per se does not have critical time limits for its learning, there is circumstantial justification for an at least heuristic optimistic view. But whereas during an optimal period for such learning, the directed teaching necessary might be minimal, as the best period passes, more and more direction and more and more optimal stimulus conditions will be necessary. This chain of hypotheses would lead, then, to a directed emphasis on the teaching of auditory discrimination to any child who shows poor skill in this area. The degree of direction and of emphasis on this skill would vary, of course, depending on the

age of the child, pending the discovery of the actual optimal times involved. But from the above reasoning, one could certainly say that such emphasis should be present in any teaching done before the child reaches the first grade. This hypothesis is further supported by the data to be presented below relevant to the relationship between auditory discrimination and verbal and reading ability.

Before proceeding to consideration of the data and their implications, however, let me point out that while, as was stated above, the kind of training indicated is highly consistent with good teaching practice, typically in pre-school installations such as nursery schools, the curriculum is a much freer one, oriented mainly toward the child's interpersonal relationships and containing therefore many more distractions which would create "noise" in the auditory system. The reasoning on auditory discrimination and its potential optimal period would imply a more school-like organization for the nursery school--at least for such functions as auditory training. If the hypotheses to be presented below about the importance of this function for many other verbal skills are borne out by further research, then the introduction of more structured periods into an unstructured program will be amply justified.

Now let us proceed to the data relating to auditory discrimination. These data were gathered in connection with several different projects[2] directed by various Institute staff members. As a result, there is inconsistency of measures employed from one sample to the next, and

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[2]The data reported here were gathered in the course of projects supported as follows: Grant MY-4438, from NIMH; Verbal Survey Project, supported by the Taconic Foundation and NIMH Grant #MH 1908-1; Cooperative Research Project #1099; and Cooperative Research Project #908.

there is also some inconsistency of statistical treatment. But all samples have in common data on auditory discrimination gathered on the Wepman Auditory Discrimination Test (Wepman, 1958).

This individually administered test consists of 40 pairs of words, 30 pairs of which differ from each other only in either the initial or final sound. Ten pairs are the same. The subject's task is to listen carefully to each pair of words and say whether they are the "same" or "different." On the tables and in the following discussion, the "same" scores refer to the number of same pairs which the child identified as same, and the "different" scores refer to the number of different pairs which the child correctly identified as different. Wepman has rough norms on the test. The method exemplified by this test has been long in use as a measure of auditory discrimination. The advantage of the Wepman test is that it is long enough to provide an adequate behavior sample, and it is highly systematized (the word-pairs selected were matched for familiarity by selecting words as close together as possible from the Lorge-Thorndike Word Book, and every possible match of phonemes used in English was made within phonetic categories, with no cross-phonetic category matching being included). While in the tables reproduced here the correlations between the Wepman "same" scores and the other variables are reported, in practice only the different scores are used or interpreted. Wepman points out in his manual for the test that the "same" items are included mainly for purposes of testing the validity of the test; he does not use them in interpreting the test findings. The same scores are, further, not comparable to

th different scores, inasmuch as there are considerably fewer some than different pairs (10 as opposed to 30). Thus, too, the actual scores obtained on the same items have a very narrow range, and the correlations between these scores and the other variables would be accordingly attenuated. It is our practice to administer the test by means of a tape recording, playing the tape through earphones, with an examiner in the room with the child and the tape recorder. The examiner was thus able to determine, at least behaviorally, if the child was attending to the stimuli.

All the other test data also were gathered according to the procedures outlined in the respective manuals. However, where the Digit Span test appears as a variable, this was administered at a time different from the administration of the WISC, and the WISC administration did not include this subtest.

Table 1 presents correlational data on the Wepman Test and various other measures, including the subtests of the WISC, the Gates reading tests, the Roswell-Chall word-parts test, and the Institute Orientation Scale. The correlations in Table 1 were obtained on a sample of 28 fifth-grade children, all of whom were retarded in reading by one to three years. Table 2 presents correlations of the same variables for a sample of 30 fifth-grade children who were not retarded in reading. All the children in the two groups are Negro; socio-economic status does not differ significantly between the two groups. Table 3 presents correlations among the two Wepman test scores, the Gates advanced reading score, the Lorge-Thorndike Intelligence Test (Intermediate Level, Non-Verbal) and the Institute Orientation Scale for a sample of 93 fifth-grade children, unselected in reading level.

Correlations between Wepman Auditory Discrimination Measured Variables for Sample of 26 Eighth Grade in Reading

	Wepman Diff. Score r	Wepman Score r
Gates Adv. Paragr. Reading	.05**	.0
Gates Oral Diagnostic	.20	.1
Roswell-Chall Sounds	.22	-.0
Roswell-Chall Words	.24	.0
Roswell-Chall Syllab.	.32	.0
WISC Info.	.36	.1
WISC Comp.	.45**	.3
WISC Arith.	.00	.2
WISC Simil.	.29	.2
WISC Vocab.	.61**	.0
WISC Verbal Scale	.52**	.3
WISC Pict. Comp.	.20	-.2
WISC Pict. Arr.	.16	.0
WISC Block Des.	-.02	.0
WISC Obj. Assem.	.07	.0
WISC Coding	-.23	.1
WISC Perf. Scale	.07	-.0
WISC Full Scale	.27	.1
Orientation Scale	.04	.0
Digit Span	.15	.1
Wepman Diff. Score		
Wepman Same Score		

Table 2

Correlations between Wepman Auditory Discrimination Test and Other Research Variables for Sample of 30 Fifth Grade Children of Average Reading Level

	Wepman Diff. Score	Wepman Same Score	Mean Score	Standard Deviation
	r	r		
Gates Adv. Passage. Reading	-.09	.25	27.2	2.7
Gates Oral Diagnostic	.23	.06	26.7	6.5
Roswell-Chall Sounds	.23	.04	23.25	4.26
Roswell-Chall Words	.23	-.01	25.3	3.97
Roswell-Chall Syllab.	.14	-.01	7.10	1.80
WISC Info.	.17	-.02	9.40	2.47
WISC Comp.	.39*	-.12	10.23	2.58
WISC Arith.	.07	.03	10.10	1.80
WISC Simil.	.03	-.04	11.10	2.39
WISC Vocab.	.31	-.06	9.87	2.39
WISC Verbal	.30	-.02	50.07	8.44
WISC Pict. Compl.	.13	-.09	10.50	3.20
WISC Pict. Arr.	.29	.03	10.10	2.45
WISC Block Des.	-.06	.14	8.67	2.88
WISC Obj. Assem.	.16	.07	8.73	2.06
WISC Coding	-.29	-.03	10.00	2.75
WISC Perf. Scale	.06	.04	48.00	8.73
WISC Full Scale	.04	-.09	98.40	22.46
Orientation Scale	.31	.13	43.60	5.41
Wepman Diff. Score			25.83	1.9
Wepman Same Score			9.73	.44

*p = .05

Table 4 presents correlations among the same variables, with the exception of the substitution of the Peabody Picture Vocabulary Test (PPVT) for the Gates reading score, for a sample of 72 first-grade children. The samples represented in Tables 3 and 4 were balanced on both race and socio-economic status: 25% of them are lower-class white, 25% are lower class Negro. They were unselected with regard to the reading variable.

The data in Tables 3 and 4 show relatively few significant correlations, but every one of them relates the Wepman score to some verbal ability. The highest correlations are with the WISC Vocabulary Score (.61) and with the WISC Verbal Score (.52, but this includes the Vocabulary sub-test) both of which are significant beyond the .01 probability level. The average correlation between the Wepman and the subtests which comprise the primary verbal factor on the WISC (Information, Comprehension, Similarities, and Vocabulary) (Cohen, 1969), was .43 which is significant between the .05 and .02 probability levels. The correlation between the Wepman and the Comprehension subtest of the WISC for this sample is .45, which is significant at the .02 level, as is the correlation with the Gates Advanced Paragraph Reading Test, which is also .45. For the normal reading group, however, the data for which are presented in Table 2, the only significant correlation is between the Wepman score and the WISC Comprehension subtest, and that value is .39, with a p value of .05. It is to be noted that in neither group is any correlation between the Wepman and a non-verbal or performance measure significant. Further, for these matched,

low socio-economic status groups, the correlations between the Wepman and the two information measures--the WISC Information subtest and the Institute Orientation Scale--are not significant either.

On examining Table 3, we find a significant relationship between the Wepman score and the Institute Orientation Scale, though only at the .05 level. Some of this difference may well be simply a statistical function of the difference in population size: the correlation reported in Table 2 is actually higher than that in Table 3, but the latter is significant because it is based on an N of 98, while the former is based on an N of 30. Another potential explanation of this difference, occurring as it does in two groups of the same age, would relate to the fact that the sample reported in Table 3 does represent a balanced group on socio-economic and racial variables. It also is unselected on reading level, and therefore, undoubtedly includes a proportion of retarded readers, while the Table 2 sample is composed of all normal readers. The contribution of these socio-economic and reading differences to the obtained result will have to be determined by further data analysis.

One other significant correlation is found with the Wepman, and that is the relationship between Wepman score and score on the Lorge-Thorndike. For this sample, in fact, it is seen that the Lorge-Thorndike correlates significantly with every other variable. It is beyond the scope of this paper to offer interpretations of these correlations; they are mentioned because, as

to turn to the data in Table 4, it can be seen that the Lorge-Thorndike correlated with none of the other measures. Since Table 4 reports data for a younger sample--first graders--of a similarly balanced socio-economic and racial composition, this difference may be relevant for the over-all interpretation of the Wepman data. Again, in Table 4, it is seen that the Wepman and the Orientation Scale are significantly correlated, and this time the significance is beyond the .01 level. The Wepman score for this group also correlates significantly with the scores on the PPVT. It might be noted that the PPVT is also an intelligence measure, but one which uses verbal behavior, while the Lorge-Thorndike form at this level is non-verbal. Here, then, we may be confirming what was noted in Table 1: the Wepman correlates with verbal measures, but not with non-verbal or performance ones. The other significant correlation for the first grade group is that between the PPVT and the Orientation Scale. This might relate to the significant relationship between the Lorge-Thorndike and the Orientation Scale for the Fifth grade group, but again, it is beyond the scope of this paper to offer interpretations of findings not related to the auditory data.

To turn for a minute from the relational data to the description of the performance of the children on the Wepman test itself, we find, in Tables 1 and 2, mean different scores of 23.15 and 25.83, with standard deviations of 3.5 and 1.9 respectively. These mean scores at this age level would both fall into Wepman's category of "inadequate development." (For children 8 and older, this category comprises all scores below 27.) The greater variability of the

retarded reader group is a consistent finding for many measures, and is evident in scanning of Tables 1 and 2. The Wepman means and standard deviations on Tables 3 and 4 are 25.49, with a sigma of 2.77 for the fifth grade sample, and 21.40 with a sigma of 6.0 for the first grade sample. These scores also fall into the "inadequate development" category. The exact meaning of these scores, however, especially for the sample included in Table 3, must remain in doubt in the absence of specific statistical breakdowns along socio-economic and reading ability parameters.

To sum up the significant relational findings in these four tables, it is possible to say that the Wepman correlates with few other measures, but that these measures include only those which relate to verbal skills. More significant relationships are found between Wepman scores and verbal measures for retarded readers than for normal readers among fifth grade children, and for first graders as opposed to fifth graders when the subjects are unselected in terms of reading ability.

Free speech samples of portions of the populations referred to in Tables 3 and 4 were analyzed on 18 verbal measures, and correlations with the Wepman score were run for each of these. The overwhelming majority of these correlations was not significant, and they are therefore not reported in tables here. However, it is well to note that the relationships which were significant would relate good Wepman performance to lack of redundancy in speech in first-grade children. In the light of the pathological speech entity known as "cluttering" this is a very interesting finding. Redundancy in speech may well be a less severe form of cluttering, and if so, as

with many speech defectives, one would expect to find reduced auditory discrimination ability. This relationship, of course, does not in itself indicate which may be causal. However, the findings with regard to decreased reading ability, and the data to be reported in later tables on other perceptual techniques, would tend to support the view that the auditory problems come first.

Now let us consider some different data, obtained on a different sample.[3] These data were treated by analysis of variance, so the results are in the form of different scores, rather than similarities. These were also replaced by technique, with a separate table for each one. The number of subjects included for each technique is indicated on the appropriate table. The subjects represented in successive tables are in most cases different children, so performance on one of the tasks cannot be related to performance on the others. All the groups had in common lower socio-economic status, and they were all boys' males. Half of them represent the upper third in reading ability in their school group, and half represent the lowest third. The highest categories on the tables refer to reading level.

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[3] I am indebted to Dr. Phyllis Katz for the organization and analysis of these data.

Table 5

Wepman Auditory Discrimination Test: Mean number of errors

Group	N	Mean
1st Low	8	13.1
1st High	8	7.8
3rd Low	8	10.0
3rd High	8	5.5
5th Low	8	7.8
5th High	8	6.9

Results of analysis of variance:

Age level:	$p < .01$
Reading level:	$p < .001$
Age x Reading level:	$p < .01$

Table 5 shows the Wepman data. From it can be seen that the Wepman differentiates good from poor readers at the .001 level of confidence. This, of course, would tend to confirm the earlier finding of a significant relationship between Wepman score and score on the Gates Reading Test, though it will be remembered that this finding was for fifth grade children who were poor readers. Table 5 also shows that the Wepman differentiated first grade children from fifth grade children, at the .01 level of confidence, and that, further, the interaction between age and reading is also significant at the .01 level. Inspection of the data underlying this last finding reveals that the differentiation between reading groups is less for the older children than for the younger ones, though it must be remembered that this differentiation remains significant for the fifth grade group.

Table 6 presents data obtained on the bi-modal reaction time apparatus.[4] Here it is seen that older children have significantly faster reaction times to stimuli in both visual and auditory modalities, and that for all of them the cross-modal reaction time is longer than the ipsi-modal. But the significant interaction reported indicates that poorer readers are disproportionately slower in cross-modal reaction time than are good readers. This substantiates a finding reported on the basis of initial studies two years ago (Rabb, Deutsch, & Freedman, 1960). Tables 5 and 6 then, would indicate that poorer readers have poorer auditory discrimination and that they have greater difficulty in shifting from one modality to another. Further, it has long been reported (for example, Woodworth and Schlosberg, 1954) that reaction time to auditory stimuli is faster

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[4]The bi-modal reaction time apparatus was first developed by Sutton and his colleagues (Sutton, Hakerem, Zubin, and Portnoy, 1961). It consists of four stimuli, presented in random-appearing pre-arranged order, to each of which the subject makes two gone responses: lifting his finger from a button. The four stimuli are a red light, a green light, a high tone, and a low tone. The measures derived are auditory and visual reaction times, ipsi-modal reaction time (reaction time to a stimulus which has been preceded by a stimulus in the same modality), and cross-modal reaction time (reaction time to a stimulus which was preceded by a stimulus in the other modality). The program of stimuli used in the experiments reported here included six blocks of 32 trials each, with a short rest between blocks. The findings of Sutton et al., indicated that schizophrenic subjects had disproportionately lengthened cross-modal reaction times; the same finding is reported for neurological patients (Benton, Sutton, Kennedy, and Lucka, 1962). Previous work by our group at the Institute indicated the same to be true for retarded readers. While our apparatus differs from that described by Sutton, the difference is in engineering rather than in outcome: most of our data gathering is done in the schools, and thus portable apparatus is necessary. Our equipment, therefore, uses transistors and relays rather than vacuum tubes, and is made in three separate units which are attached to each other at the site of data gathering.

that that be valid, and yet the present sample does not show this difference. While negative findings can be considered suggestive at best, this was done nothing to dispel the assumption of inferior auditory functioning on the part of retarded readers.

Table 7

Correlations Performance Test - Combinational Form: Main percent correct response

		Modality		
Ex. Gr.	N	Auditory	Visual	Total
Exp. Low	8	69.8	65.5	62.8
Exp. High	8	62.7	54.1	58.4
Exp. Tot	16	71.4	69.8	60.4
Con. Low	8	63.5	43.4	63.4
Con. High	8	78.7	75.5	77.1
Con. Tot	16	81.1	59.4	70.3
Tot. Low	8	67.5	85.9	66.7
Tot. High	8	66.5	67.0	66.7
Total Grp.	16	67.0	66.4	66.5
Total Mean	32	73.8	65.2	72.5

Results of analysis of variance:

Age Level:	$p < .01$
Modality:	$p < .01$
Reading level x modality:	$p < .05$

Table 7 reports the data on the combined form of the Continuous Performance Test (CPT)[5]--that is, the form in which the auditory and visual stimuli are introduced. Here we see a reversal in the trend of the findings: The response to the auditory stimuli was more correct than to the visual, and the interaction between reading level and modality indicates that the auditory functioning was disproportionately superior for the retarded readers. Katz (1962) has explained this finding in terms of different strategies of approach on the part of the good and the poor readers: she believes that the poor readers attend only to stimuli in one modality and block out the other. Such a theory, which seems eminently plausible in view of the data, would explain again the difficulty for the retarded readers of shifting from one modality to the other. It must be pointed out here that the auditory task for the subject on the CPT is quite different from the one presented by the Wepman. On the CPT, discrimination is called for, but it is between names

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[5]The CPT was developed by Rosvold, Mirsky, and their associates, who report that it successfully differentiates between brain-damaged and normal subjects (Rosvold et al., 1956). The form of the technique developed originally presented a series of letters visually to the subject. He was told to depress a button each time he saw the letter "X". The task was then complicated, with the subject being told to press the button only when "X" had been preceded by "A". At the Institute, since our subjects are children and many of them are retarded in reading, it was felt that letter stimuli were inappropriate. We have, as a result, developed a program for the test which uses colored dots. We have also developed an auditory analogue to the test: the child hears the names of colors read (presented by means of a tape recorder) and is told to press the button when he hears the appropriate stimulus color (red). The combined form consists of both visual and auditory stimuli, presented in random order. In all cases the "correct"

of colors, nine of which sounds very similar to the "correct" color (i.e., the one in response to which the subject is to press the button) which is "red". On the Wepman, of course, the pairs of words presented differ minutely, and only at either the beginning or the end of the words. Further, the stimuli on the CVP are presented serially, and a judgment is required for each one, while the Wepman stimuli are pairs of words.

Table 8

Serial Learning Task: Mean number of correct repetitions

Group	N	Modality: Auditory	Visual	Auditory-Visual	Total
1st Low	8	83.6	96.9	78.0	258.5
1st High	8	109.5	106.8	110.6	326.9
2nd Low	8	94.1	105.1	100.6	299.8
2nd High	8	108.4	112.0	113.2	331.6
3th Low	8	104.5	111.0	109.4	324.9
3th High	8	109.0	110.4	116.1	335.5
Total	48	101.3	107.0	104.6	

Results of analysis of variance:

Age level:	$p < .005$
Reading level:	$p < .005$
Age x reading level:	$p < .025$
Modality:	$p < .025$
Modality x reading level:	$p < .025$

When we consider data pertaining to the modalities for learning, we find once again performance with auditory presentation. The between the visual and the auditory modali case of the young readers, and the poorer in serial learning generally. The older chi quickly than the younger ones, and this is on Digit Span performance, reported in Table

Table 9

Digit Span: Mean number co

Modality

Group	N	Auditory	
1st Low	16	4.0	
1st High	16	4.5	
3rd Low.	16	4.1	
3rd High	16	5.4	
5th Low	16	5.2	
5th High	16	5.2	

Results of analysis of variance:

Age level:	$p < .001$
Reading level:	$p < .001$
Modality:	$p < .001$
Age x modality:	$p < .01$

from the poorer readers are present. The differences in favor of auditory discrimination found here are suspect, as Katz (1962) reports that several of the first grade children did not recognize the numbers when they were presented visually. If on further study of only older children who recognize the printed numbers, the auditory differences is confirmed, that might be related to the similar finding on the CVT. Here, however, it would be necessary to evaluate the results in terms of the relative verbal-ness of the stimulus material. As Milner (1962) points out, even the effects of brain lesions can differ depending on the content of the stimulus material used to test the function. She says that the degree to which the material is verbal is the crucial parameter.

Tables 5 through 9 can be summed up in terms of the characteristics of poor readers: they have more difficulty with auditory discrimination, they have greater difficulty in shifting from one modality to another and back again, and they are more inefficient at a serial learning task when the stimuli are auditory than when they are visual. In all these findings, the performance of poorer readers is related to better readers parallels the performance of younger children as compared with older ones. It will also be remembered that in the data presented earlier, the poor readers showed higher correlations between auditory discrimination and verbal and intelligence measures, and that the younger children showed also a greater relationship between the auditory measure and the verbal measures. Further, the retarded readers showed a significant relationship between auditory discrimination and reading score, while this was

not true of the normal readers of the same age and socio-economic background.

There are two discrepancies in this picture: the poorer as well as the better readers make better scores on the auditory presentations on the CVE, and also on the auditory presentation on the Digit Span. The importance of this discrepancy will have to be evaluated in the light of further data analysis: the relative scores on the all-auditory and the all-visual forms of the CVE (that presented in the combined form only) and further evaluation of the Digit Span, excluding children who do not recognize the numbers visually.

In returning to the main body of the results, however, one is struck by the apparent importance of auditory discrimination and general auditory responsiveness to verbal performance and to reading ability specifically. Such a finding would have support in Hardy's (1968) analysis of reading disabilities in terms of disorders of communication. Besides, if one uses his three-function analysis of auditory mechanisms, involving tracking of the acoustic stimuli, it is necessary to regard auditory discrimination and recognition as basic to the more advanced processes. These are 1) processing (ability to perceive rapidly successive bits of information, as in perceiving speech); 2) patterning (capacity to relate this information in terms of significance to past and present behavior); and 3) retention. In these terms, discrimination between sounds presented successively and recognition of sounds singly or in patterns would be basic to both reception and

expressive communication skills. Further, these receptive and expressive skills cannot be separated into two distinct functions, but must be seen as aspects of the same basic language process. If reading does belong in that category, then it is highly likely that a skill which underlies other aspects of communication processes would also be strongly related to and influential in the development of reading ability.

The similarity between the retarded readers and the younger children leads to an hypothesis of immaturity in these basic functions on the part of the retarded readers. This would support Bilikoch's (1957) hypothesis of "neurophysiological immaturity" in many children with reading and with language defects. Since in the absence of irreversible brain lesions (or of a critical time postulate which would indicate that the critical time was past), immature skills can mature, it is possible to construe the age/reading skill interrelations as evidence for the maturation of the functions under consideration.

Most reading-readiness tests in current use emphasize readiness in terms of visual perceptual skills, rather than auditory ones. Most of these tests have been constructed with middle-class subjects in mind. Most of the subjects who contributed to the data presented here were lower-class children. If the hypotheses presented in the first part of this paper can be accepted, it may well be that lower-class children, who live in very noisy environments, do not develop the requisite auditory discrimination abilities to learn to read well--or adequately--early in their school careers, while middle-class

children from quieter and more speech-directed environments would not have this problem. It is not meant here to imply that all children from disadvantaged environments are going to be poor in auditory discrimination, while all middle-class children are going to have adequate skill in this area, but, rather, that the conditions under which children live, particularly early in life, are going to affect auditory skill in a predictable way. Within this framework, large individual differences are possible among children who live in close proximity to one another, depending, for example, on the amount of speech and other meaningful auditory "signal" which is directed toward them. Middle-class children do live in a more speech-directed environment and so they have a less noisy and crowded one (i.e., there is both more signal and less noise to the speech), and this would have a direct effect on their auditory skills.

Now it might be that auditory discrimination skills which develop early in middle-class children would not influence auditory discrimination problems in the disadvantaged as much as would auditory skills in the child from deprived areas. This is not to say that reading experts have not known all along that auditory functioning was involved in reading, but only that it has been the visual which has been stressed--and successfully with middle-class children. But the discrepancy in incidence of reading retardation between middle-class and lower-class children is very large, and it is possible that at least a portion of this discrepancy is attributable to differential conditions for auditory discrimination. This is, of course, a testable hypothesis.

This reasoning leads me to postulate that a particular minimum level of auditory discrimination skill is necessary for the acquisition of reading and of general verbal skills. Once that minimum level is reached, perhaps, auditory discrimination is no longer highly correlated with these abilities. If this were true, it would account for the decreasing differentiating ability of auditory tasks as children--retarded and normal readers--get older. Of course, even if the auditory skills should mature simply as a result of time and the children's exposure to the school situation, without specific recognition of the problem, and training in the area, it would be possible for children with such deficiencies--or immaturities--to fall far behind in many aspects of their school work and thus be unable to catch up, even when the deficiency is overcome. This would, of course, underline the importance of training in auditory discrimination early in the school experience. Certainly a test of auditory discrimination ability in the first grade would be helpful in any preventive program directed to [illegible] a population in which the base rate of reading retardation is already high.

In any event, this thesis paper has been concerned with the interaction and interdependence between the more social and the more biological factors in human development. Auditory discrimination is already a function mediated by the nervous system; yet it can be profoundly influenced by the conditions of life of the individual, and it, in turn, can affect his relationship to his environment and the people in it. Learning to listen is guided by [illegible] skills, and others, the mature [illegible]

is very susceptible to influences from the mother's nutritional status, and this in turn is strongly influenced by the socio-economic status of the mother. Thus, not only does man's environment influence him, but it may be that it plays a role in molding his very reactive processes to it. This holds out great promise for the potential effects of programs such as our pre-school enrichment which are designed to vitiate the deleterious effects of deprived environments. Such programs might really effect lasting changes.

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